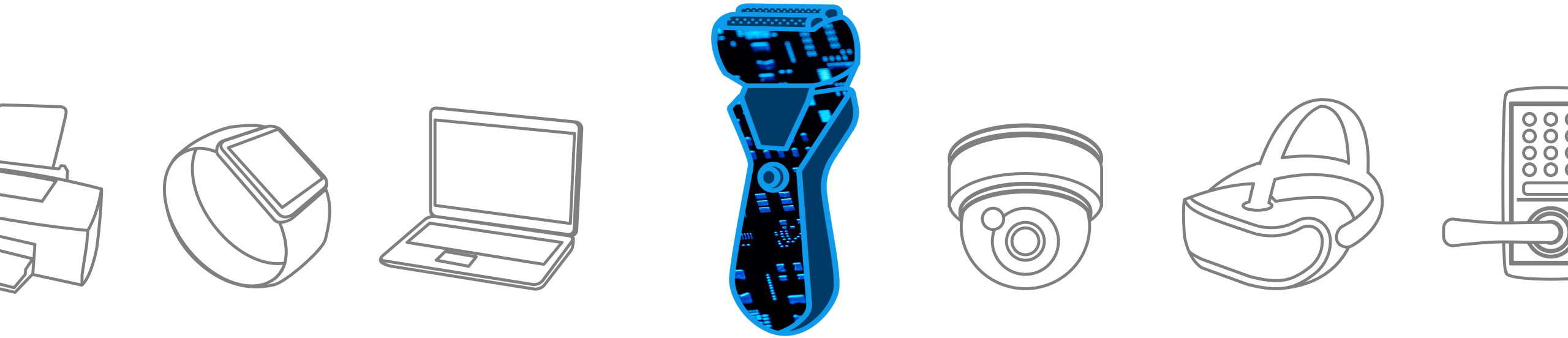
TOSHIBA

R23

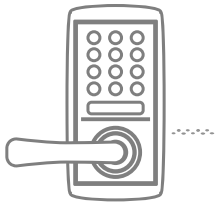
Electric Shaver

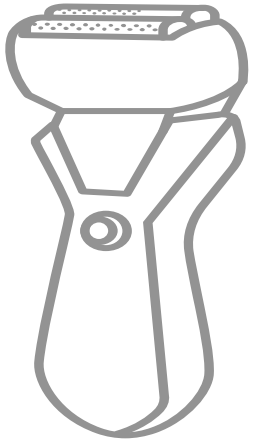
Solution Proposal by Toshiba



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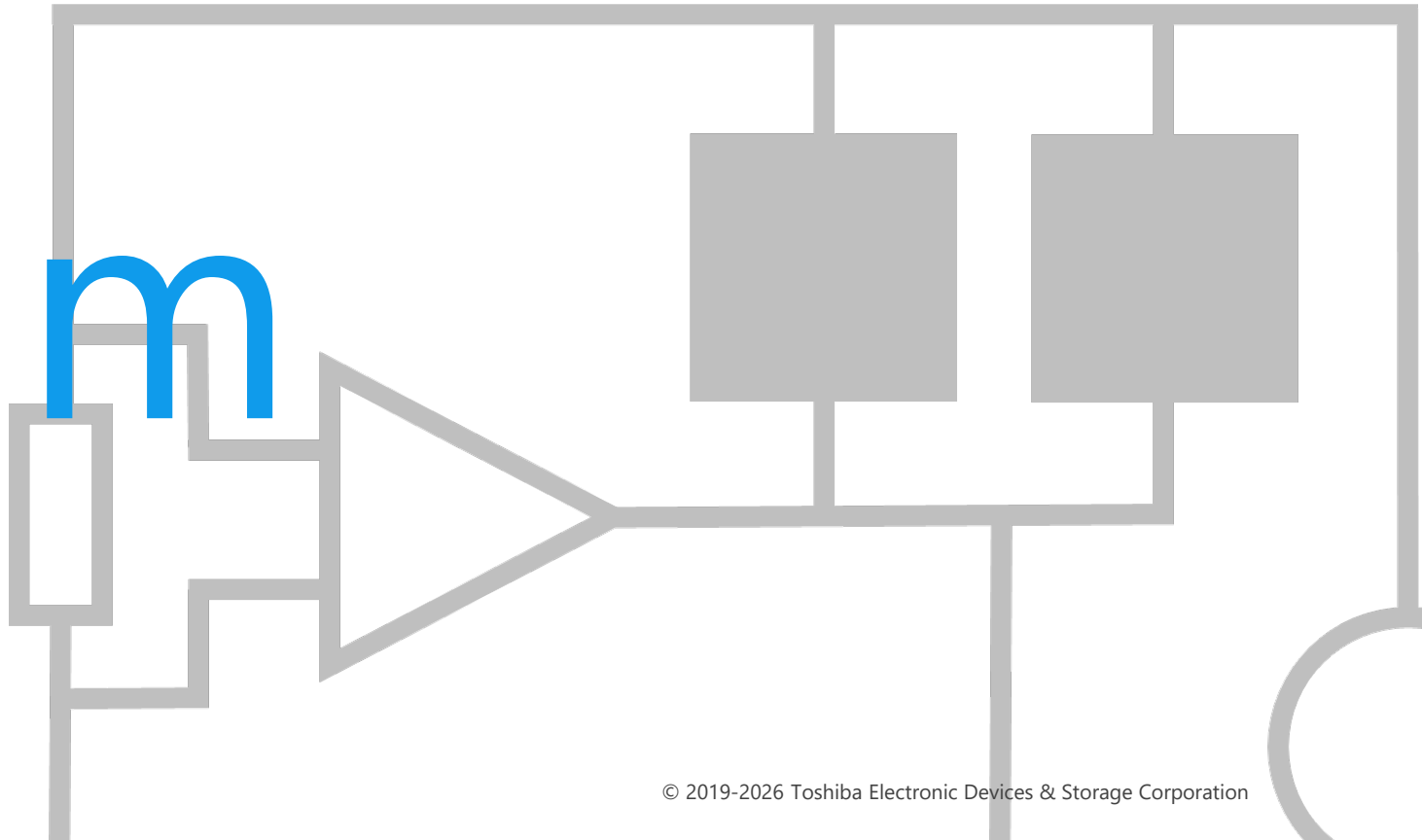




Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

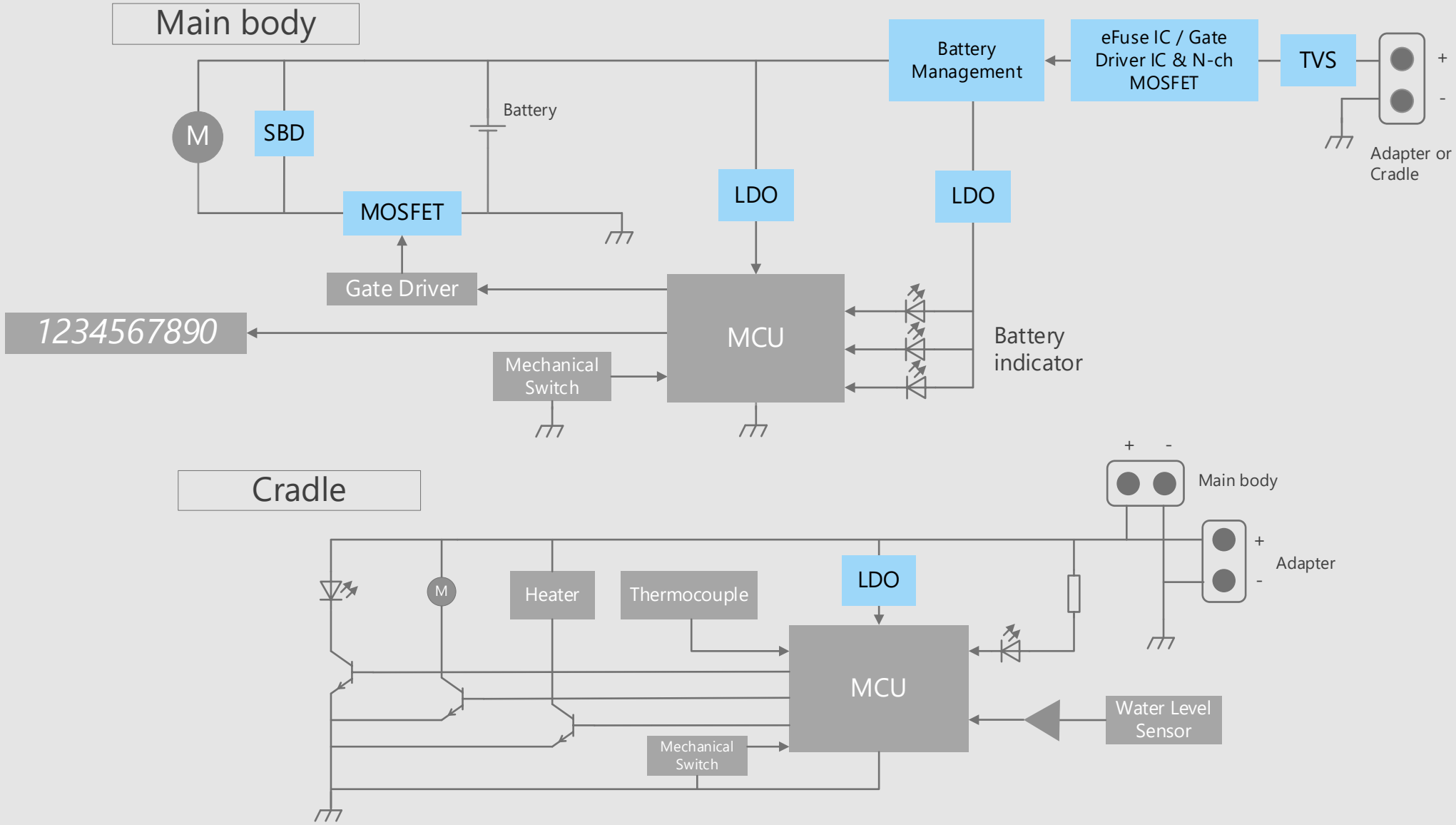
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Block Diagram



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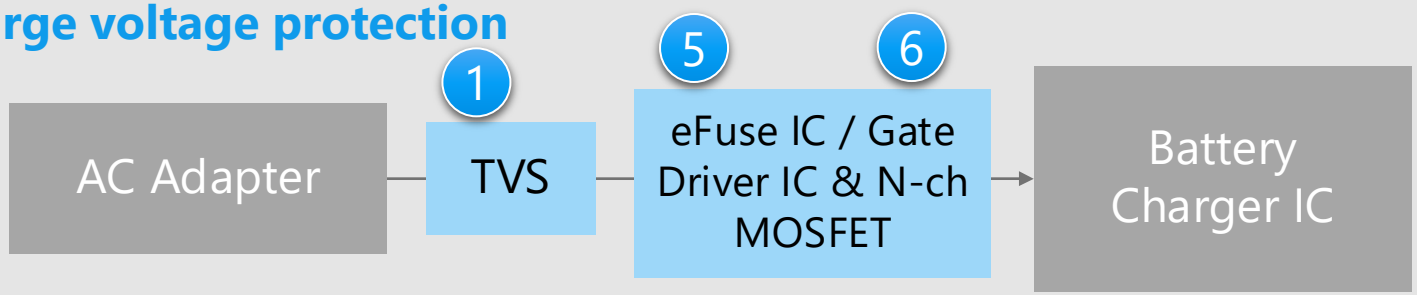
Electric Shaver　Overall block diagram



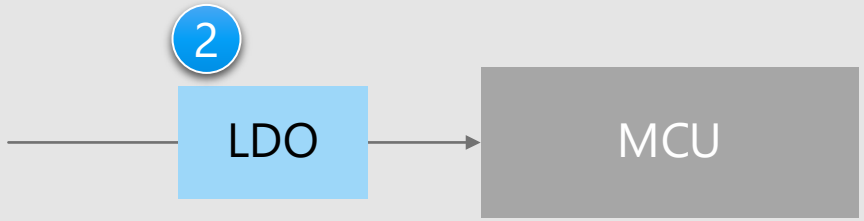
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Electric Shaver　Detail of power supply section

Surge voltage protection



Control MCU power supply



Constant voltage supply circuit



<u>* Click the number in the circuit diagram to jump to the detailed description page</u>

Criteria for device selection

- ESD protection is required for the power line when the AC adapter is not connected.
- LDO regulators are suitable for supplying stable voltage.
- eFuse ICs with various protection functions are suitable for stable operation of the set.

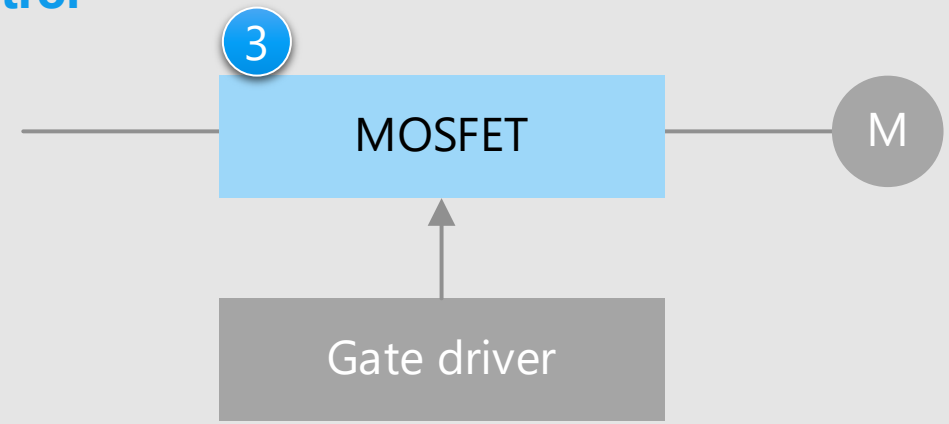
Proposals from Toshiba

- **Static electricity (ESD) from external terminals is absorbed to prevent circuit malfunction and device breakdown** 1
  TVS diode
- **Stable voltage supply** 2
  Small surface mount LDO regulator
- **Built-in protection function against short circuit, over current, over voltage, etc.** 5
  Electronic fuse (eFuse IC)
- **Small package and built-in over voltage protection function** 6
  N-ch MOSFET gate driver IC

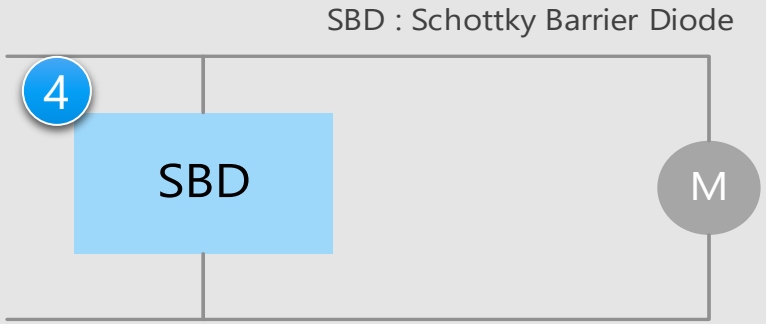
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Electric Shaver　Detail of motor drive section

Motor control



Motor protection



* Click the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

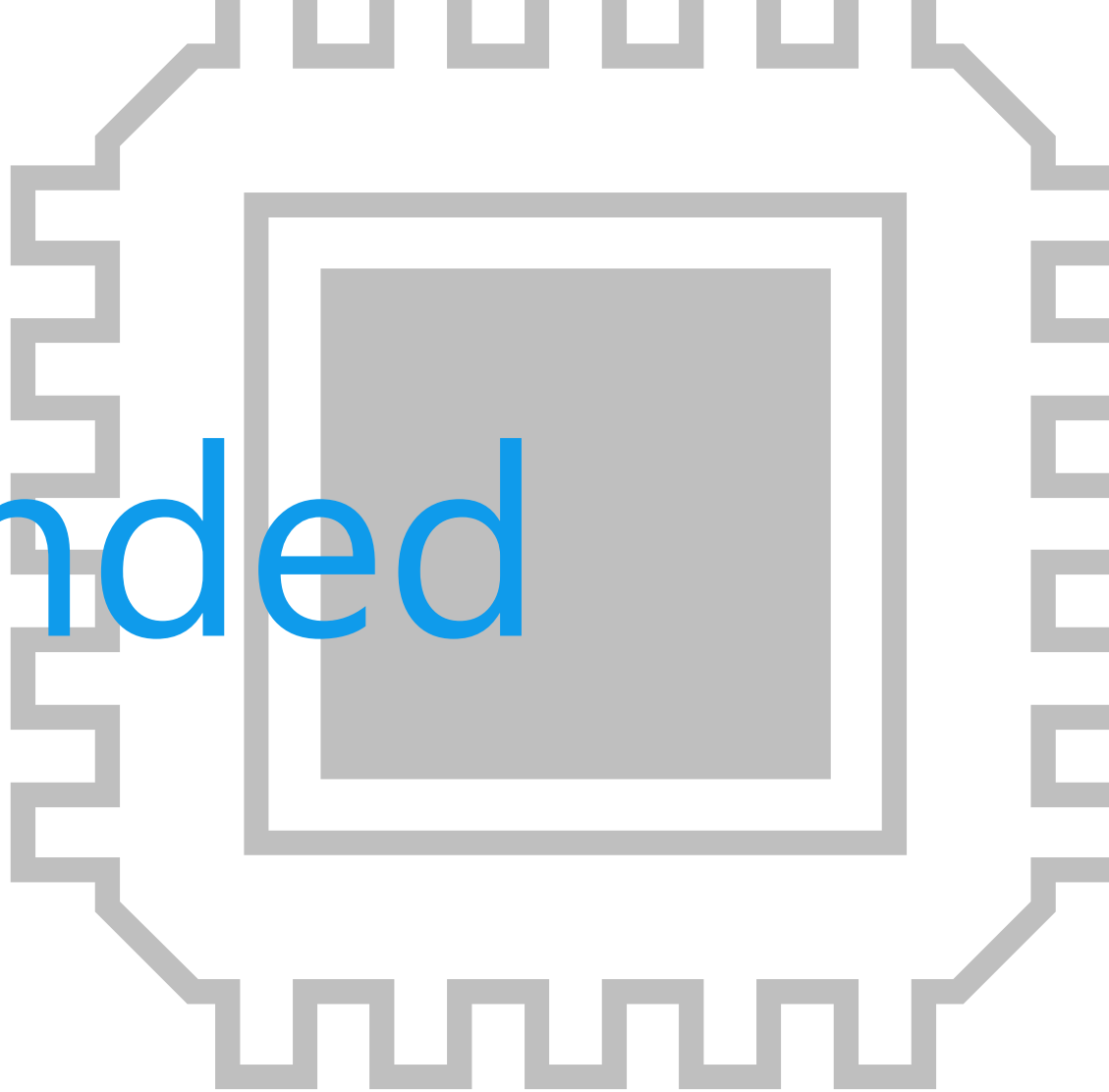
- MOSFET with small package and low on-resistance is used to control the motors.
- Protection against regenerative current by the motor is necessary.

Proposals from Toshiba

- **Realize a set with low power consumption by low on-resistance**
  Small signal MOSFET 3
- **Low forward voltage / Strong against surge current**
  Schottky barrier diode 4

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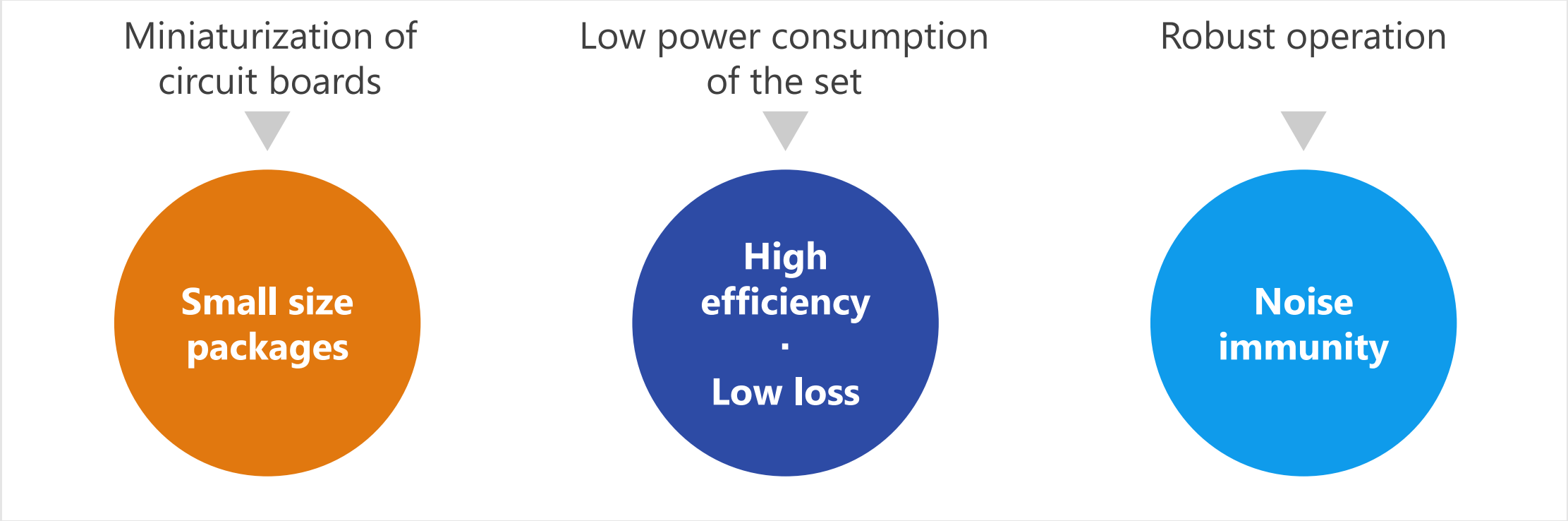
Recommended Devices



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Device solutions to address customer needs

As described above, in the design of electric shaver, **“Miniaturization of circuit boards”**, **“Low power consumption of the set”** and **“Robust operation”** are important factors. Toshiba’s proposals are based on these three solution perspectives.



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Device solutions to address customer needs

	Small size packages	High efficiency · Low loss	Noise immunity
1 TVS diode	●	●	●
2 Small surface mount LDO regulator	●	●	●
3 Small signal MOSFET	●	●	
4 Schottky barrier diode	●	●	●
5 Electronic fuse (eFuse IC)	●	●	
6 N-ch MOSFET gate driver IC	●	●	

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1 TVS diode

DF2B7BSL / DF2B20M4SL / DF2B5PCT / DF2B7PCT / DF2B7AFU

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

This absorbs static electricity (ESD) from external terminals, prevents circuit malfunction and protects devices.

1 High ESD pulse absorption performance

Improved ESD absorption compared to Toshiba's existing products. (50 % reduction in operating resistance)
For some products, both low operating resistance and low capacitance are realized and ensures high signal protection performance and signal quality.

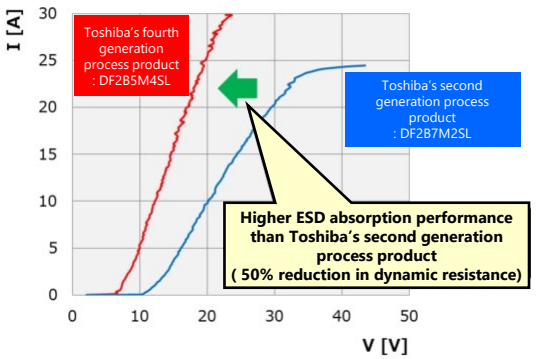
2 Suppress ESD energy by low clamp voltage

Protect the connected circuits and devices using Toshiba own technology.

3 Suitable for high density mounting

A variety of small size packages are available.

ESD Pulse Absorption Performance
(Toshiba internal comparison)

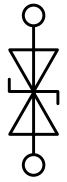


Unidirectional



Suitable for paths such as logic signals. There are lineups of 1in1, 2in1, 4in1, 5in1, 7in1.

Bidirectional



Suitable for paths with both polar signals such as audio signals.

Lineup

Part number	DF2B7BSL	DF2B20M4SL	DF2B5PCT	DF2B7PCT	DF2B7AFU
Package	SOD-962 (SL2)  Top view  Bottom view		SOD-882 (CST2)  Top view  Bottom view		SOD-323 (USC) 
V_{ESD} [kV]	±30	±15	±30	±30	±30
V_{RWM} (Max) [V]	5.5	18.5	3.6	5.5	5.5
C_t (Typ.) [pF]	12	0.2	41	45	8.5
R_{DYN} (Typ.) [Ω]	0.2	0.2	0.1	0.1	0.2

[Note] This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

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2 Small surface mount LDO regulator

TCR15AG / TCR8BM / TCR5FM / TCR5RG / TCR3RM / TCR3U / TCR3LM / TCR3D / TCR3EM / TCR1HF Series

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

Wide lineup from general purpose type to WCSP (Wafer Level Chip Size Package) type are provided. Contribute to realize a stable power supply.

1 Low dropout voltage

Low dropout voltage characteristic has been realized by the originally developed process.

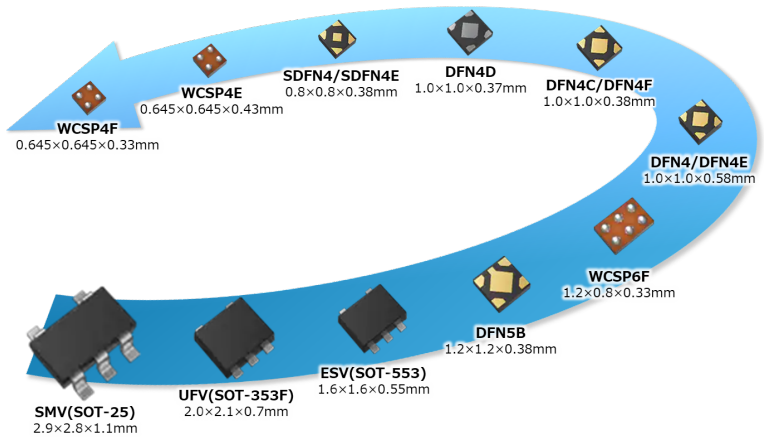
2 High PSRR Low output noise voltage

Many product series that realize both high PSRR (Power Supply Rejection Ratio) and low output noise voltage characteristics are provided. They are suitable for stable power supply for analog circuit.

3 Low current consumption

$I_{B(ON)}$ of 0.34 μA (typ.) @I_{OUT} = 0 mA, V_{OUT} ≦ 1.5 V is realized by utilizing CMOS process and unique circuit technology. (TCR3U Series)

Rich package lineup



Lineup

Part number	TCR15AG Series	TCR8BM Series	TCR5FM Series	TCR5RG Series	TCR3RM Series	TCR3U Series	TCR3LM Series	TCR3D Series	TCR3EM Series	TCR1HF Series
Features	Low dropout voltage High PSRR		High PSRR Low noise Low current consumption			Low current consumption		Standard type		36 V Input voltage
I_{OUT} (Max) [A]	1.5	0.8	0.5		0.3					0.15
PSRR (Typ.) [dB] @f = 1 kHz	95	98	91	100	100	70	-	72	68	70
I_B (Typ.) [μA]	25	20	10	7	7	0.34	1	86	35	170

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3 Small signal MOSFET

SSM3K123TU / SSM3K35AMFV

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

Suitable for power management switches and contributes to miniaturization.

1 Low voltage drive

Operate down to V_{GS} = 1.5 V

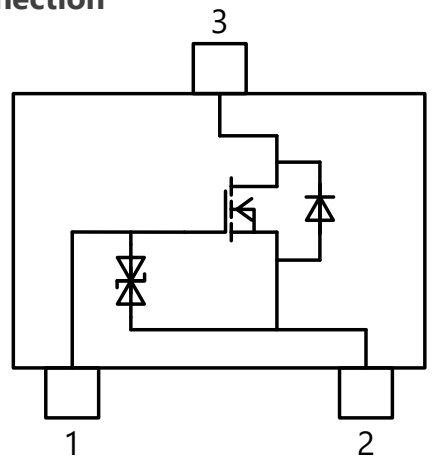
2 Low on-resistance

On-resistance between the source and drain is low. Heat generation and power consumption can be kept low.

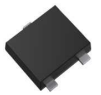
3 Small size package

SOT-323F (UFM) / SOT-723 (VESM) are small size packages.
SOT-323F (UFM): 2.0 x 2.1 x 0.7 mm
SOT-723 (VESM): 1.2 x 1.2 x 0.5 mm

SSM3K123TU Internal connection



Lineup

Part number	SSM3K123TU	SSM3K35AMFV
Package	SOT-323F (UFM) 	SOT-723 (VESM) 
V_{DSS} [V]	20	
I_D [A]	4.2	0.25
$R_{DS(ON)}$ (Max) [Ω] @V_{GS} = 1.5 V	0.066	3.1
Polarity	N-ch	

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4 Schottky barrier diode
CUS357

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

It can be applied to various applications at low loss, and contributes to miniaturization.

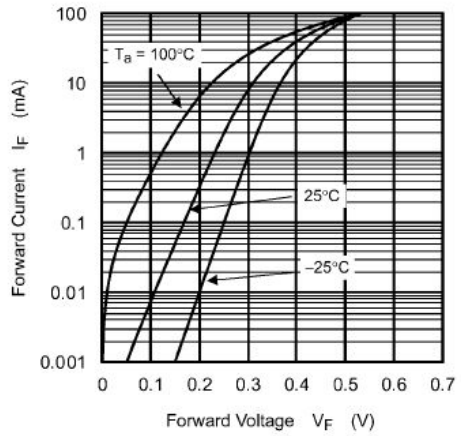
1 Low forward voltage

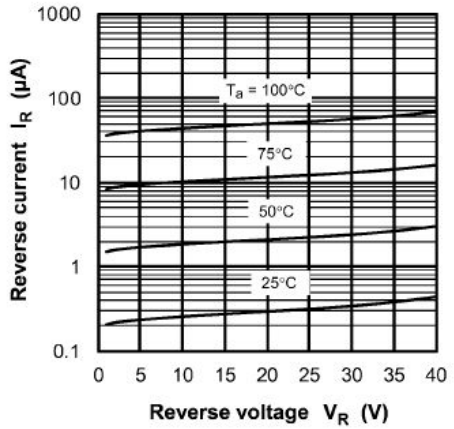
Since the forward voltage is low, it is suitable for use as a freewheel diode.

2 Small size package

SOD-323 (USC) is a small size package with 2.5 x 1.25 x 0.9 mm.

CUS357 Characteristics Curves





Lineup

Part number	CUS357
Package	SOD-323 (USC)  Top view  Bottom view
I_O [A]	0.1
V_R [V]	40
V_F (Typ.) [V] @I_F = 100 mA	0.54

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5a Electronic fuse (eFuse IC)

TCKE8 Series / TCKE7 Series

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as over current and over voltage.

1 Can be used repeatedly

When over current flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. Unlike conventional fuses, eFuse IC can be used repeatedly.

2 IEC 62368-1 certified

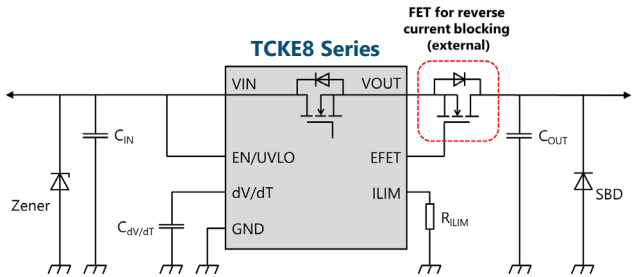
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3 Rich protection functions

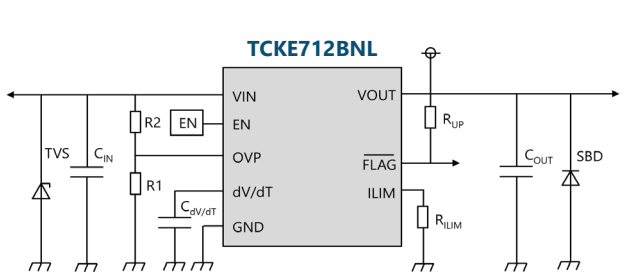
TCKE8 Series: short circuit protection, over current protection, over current clamp function, over voltage clamp function, thermal shutdown, inrush current suppression, backflow prevention (optional), etc.

TCKE7 Series: short circuit protection, over current protection, over voltage protection, thermal shutdown, FLAG signal output, backflow prevention (built-in), etc.

Example of peripheral circuit for TCKE8 Series



Example of peripheral circuit for TCKE7 Series



Lineup

Part number	TCKE800NA/NL	TCKE805NA/NL	TCKE812NA/NL	TCKE712BNL
Package	WSON10B 3.0 x 3.0 x 0.75 mm  Top view  Bottom view			WSON10 3.0 x 3.0 x 0.75 mm 
V_{IN} [V]	4.4 to 18.0			4.4 to 13.2
R_{ON} (Typ.) [mΩ]	28			53
Fault response	NA: Auto-retry NL: Latched (external signal control)			Latched (external signal control)
V_{OVC} (Typ.) [V]	-	6.04	15.1	Adjustable

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Electronic fuse (eFuse IC)

TCKE9 Series

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as over current and over voltage.

1 Can be used repeatedly

When over current flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. Unlike conventional fuses, eFuse IC can be used repeatedly.

2 Product selection is possible according to usage

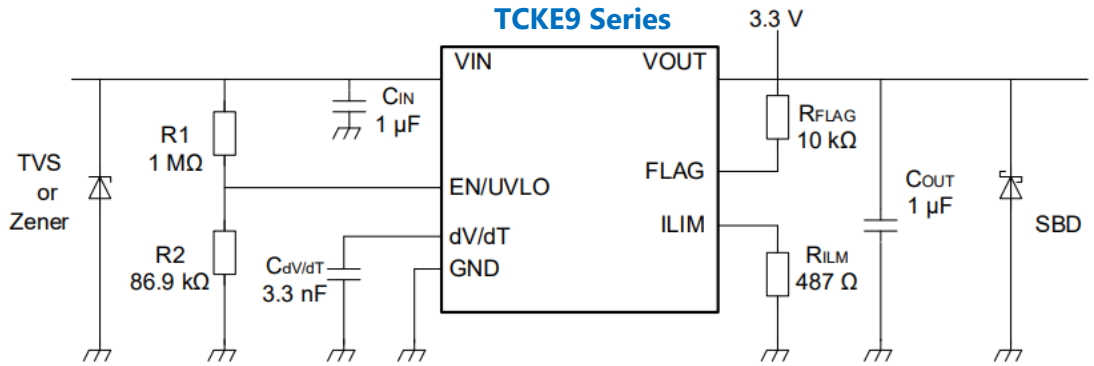
Suitable product with suitable failure response can be selected according to usage.

NA: Auto-retry type
QNA: Auto-retry with quick output discharge type
NL: Latched type

3 Rich protection functions

TCKE9 Series feature many protection functions such as adjustable over current limit, short circuit protection, over voltage clamp, adjustable under voltage protection and thermal shutdown.

Example of peripheral circuit for TCKE9 Series



Lineup

Part number	TCKE903NA/NL/QNA	TCKE905ANA/NL/QNA	TCKE912NA/NL	TCKE920NA/NL
Package	WSON8 2.0 x 2.0 x 0.75 mm	 Top view	 Bottom view	
V_{IN} [V]	2.7 to 23			
R_{ON} (Typ.) [mΩ]	34			
Fault response	NA: Auto-retry (QNA: with quick output discharge), NL: Latched			
V_{OVC} (Typ.) [V]	3.87	5.7	13.7	22.2

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Electronic fuse (eFuse IC)

TCKE6 Series

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as over current and over voltage.

1 Can be used repeatedly

When over current flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. Unlike conventional fuses, eFuse IC can be used repeatedly.

2 Product selection is possible according to usage

Suitable product can be selected according to usage.

FLAG function: TCKE601RA/RL

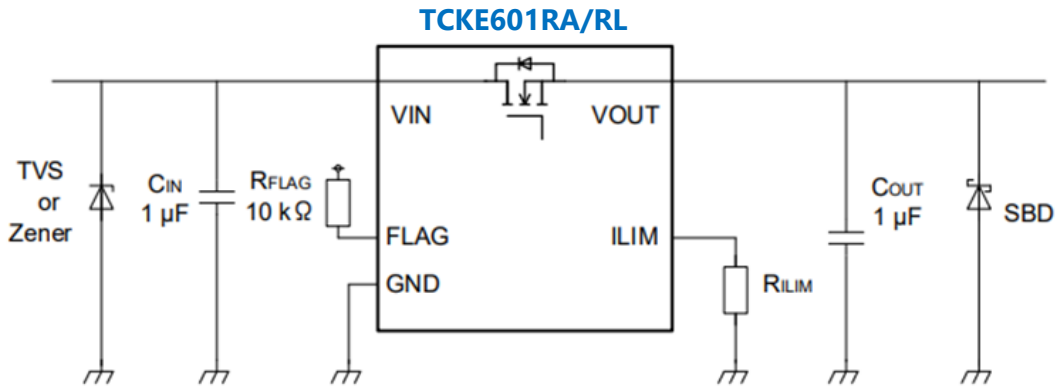
MODE function (selectable recovery mode): TCKE602RM

EN (enable) function: TCKE603RA/RL

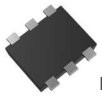
3 Rich protection functions

TCKE6 Series feature many protection functions such as adjustable over current limit, short circuit protection, under voltage protection and thermal shutdown.

Example of peripheral circuit for TCKE601RA/RL



Lineup

Part number	TCKE601RA	TCKE601RL	TCKE602RM	TCKE603RA	TCKE603RL
Package	TSOP6F  Top view  Bottom view				
V_{IN} [V]	4.4 to 30				
R_{ON} (Typ.) [mΩ]	52				
Function	FLAG		MODE	EN	
Fault response	Auto-retry	Latched	Selectable type	Auto-retry	Latched

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Electronic fuse (eFuse IC)

TCKE5 Series

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as over current and over voltage.

1 Can be used repeatedly

When over current flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. Unlike conventional fuses, eFuse IC can be used repeatedly.

2 Product selection is possible according to usage

Suitable product with suitable failure response can be selected according to usage.

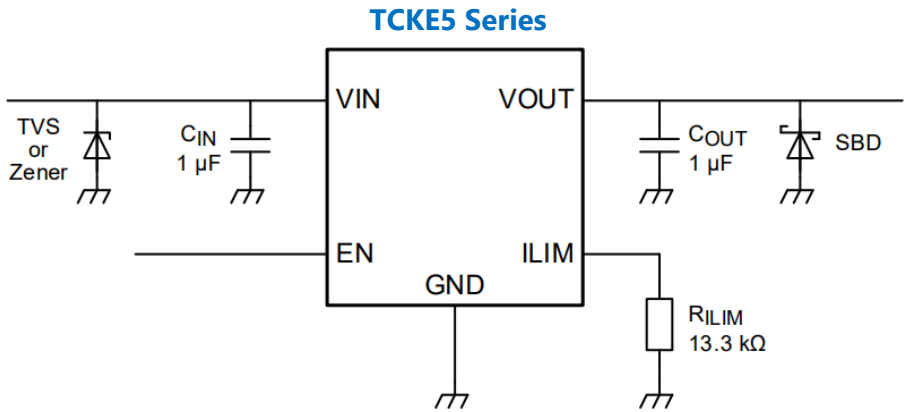
UA: Auto-retry type

UL: Latched type

3 Rich protection functions

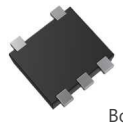
TCKE5 Series feature many protection functions such as adjustable over current protection, short circuit protection and overheat protection (thermal shutdown).

Example of peripheral circuit for TCKE5 Series



[Note2] EN: EN is the enable terminal for the output voltage. Active high.

Lineup

Part number	TCKE501UA	TCKE502UA	TCKE501UL [Note1]	TCKE502UL [Note1]
Package	SOT-353F (UFV)  Top view  Bottom view			
V_{IN} [V]	1.7 to 5.5			
R_{ON} (Typ.) [mΩ]	75			
Fault response	Auto-retry		Latched	

[Note1] Under development

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6 N-ch MOSFET gate driver IC

TCK4xx Series

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

It is N-ch MOSFET gate driver IC with OVP [Note 1] function. It contributes to reduction of power consumption and miniaturization of load switch circuit.

[Note 1] OVP: Over Voltage Protection

1 Three types of N-ch MOSFET can be driven

The following types of MOSFET can be driven:
TCK40xG: Single high side connection
Common source connection
TCK42xG: Single high side connection
Common drain connection

2 Wide operating voltage range and various OVLO [Note 2] threshold voltage

Operating voltage V_{opr}: 2.7 to 28 V
Maximum input voltage: 40 V
V_{IN_OVLO} [Note 3] lineups suitable for 5 to 24V power supply line.

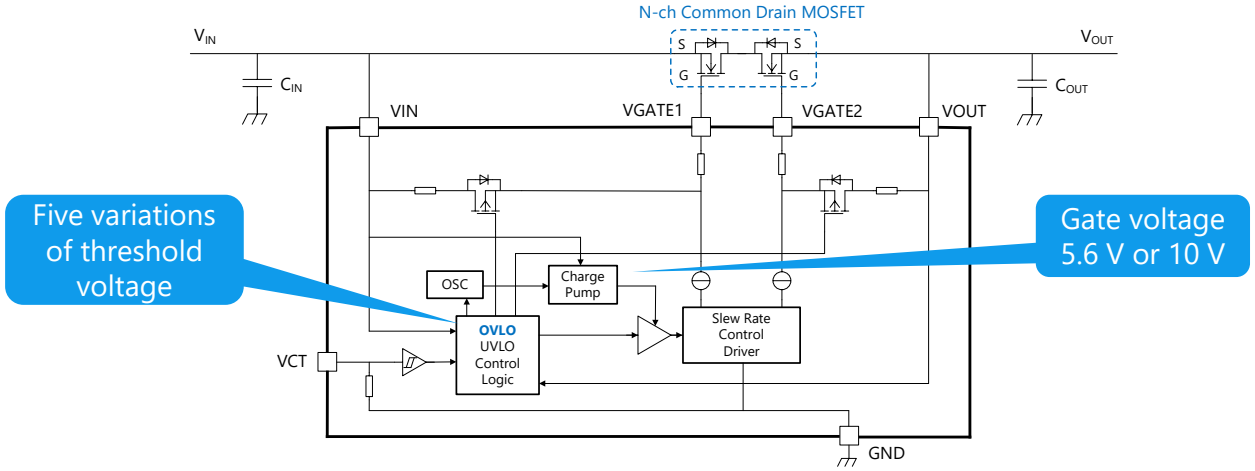
[Note 2] OVLO: Over Voltage Lock Out
[Note 3] V_{IN_OVLO}: V_{IN} OVLO threshold

3 Small size packages

It contributes to reduction of the mounting area and miniaturization of the circuit board :

WCSP6E: 1.2 x 0.8 mm, t: 0.55 mm
WCSP6G: 1.2 x 0.8 mm, t: 0.35 mm

Circuit example of TCK42xG with N-ch common drain connection MOSFET



Lineup

Part number	V_{IN_OVLO} Min / Max [V]	V_{GS} Typ. / Max [V]	N-ch MOSFET type can be driven	Package
TCK401G	Over 28	Max 10 (V_{IN} ≥ 12 V)	Single high side Common Source	WCSP6E
TCK402G				
TCK420G	26.50 / 28.50	10 / 11 (V_{IN} ≥ 5 V)	Single high side Common Drain	WCSP6G
TCK421G	22.34 / 24.05			
TCK422G	13.61 / 14.91			
TCK423G	13.61 / 14.91	5.6 / 6.3		
TCK424G	10.35 / 11.47			
TCK425G	5.76 / 6.87			

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